TECHNICAL NOTE
ORP-75-1

OPERATIONS REPORT

A SURVEY OF THE FARALLON ISLANDS 500-FATHOM RADIOACTIVE WASTE DISPOSAL SITE

DECEMBER 1975

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS
and
OFFICE OF WATER PROGRAM OPERATIONS
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FOREWORD

The Marine Protection, Research, and Sanctuaries Act of 1972, as amended, requires that the Environmental Protection Agency develop criteria and standards governing ocean dumping of all forms of waste. The Office of Radiation Programs has specific responsibility for developing regulations and criteria to control the ocean dumping of radioactive wastes.

In order to promulgate the controls necessary to protect both the public health and safety and to assure the quality of the marine environment with respect to any proposed dumping of radioactive waste, the Office of Radiation Programs initiated feasibility studies to determine whether current technologies could be applied towards determining the fate of radioactive wastes dumped in the past. Although the United States dumped radioactive wastes into ocean waters from 1946 to 1970, no dumpsite surveys had been successful in locating any of the disposal containers.

The present Operations Report provides information on the first of the EPA feasibility studies and is an account of the successful attempt to locate containerized radioactive wastes using a remote-controlled submersible. Documentation is presented here giving some preliminary evidence of the fate of the containerized radioactive wastes dumped in this site. A separate technical report will also be issued early in 1976 presenting detailed analytical results of the survey.

The success of this ocean dumpsite survey was the result of cooperation by many organizations and individuals. Special program support was given by:

U.S. Environmental Protection Agency
Criteria and Standards Division, ORP, Washington, D.C.
Marine Protection Branch, OSMCD, OWPO, Washington, D.C.
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Environmental Monitoring and Support Laboratory, Las Vegas, Nevada

Interstate Electronics Corporation, Anaheim, California

Naval Undersea Center, U.S. Navy, San Diego, California

Particular appreciation and acknowledgment is extended to the following individuals for their participation during the actual oceanographic operation and the subsequent preparation and review of this Operations Report:

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FOREWORD

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Readers of this report are encouraged to inform the Director, Technology Assessment Division (AW-459), Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., 20460, of any errors or omissions. Requests for additional information are invited.

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ABSTRACT

This report presents the operational chronology and representative photographic data, including benthic color plates, from an oceanographic investigation near the Farallon Islands, a small group of islands located WSW of San Francisco, California. The purpose of this operation was to determine the feasibility of using a submersible to locate and investigate a site used in the early 1950's for disposal of radioactive wastes and determine the conditions of the containers, primarily 55-gallon drums. The operation employed the U.S. Navy's Cable-Controlled Underwater Recovery Vehicle (CURV III). Radioactive waste containers were located at 850-meter and 900-meter depths. Precision navigation methods were used to ensure that the site could be located again for any future studies and a detailed bathymetric map of the survey area was drawn up. Sediment grab samples and cores were taken adjacent to the containers, and a sample of marine sponge was collected off one of the containers. Extensive benthic photography and video recording were utilized for documentation of the bottom targets that were investigated. Although some containers appeared to be partially crushed and breached, the majority appeared intact.

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INTRODUCTION

1.1 HISTORY OF DUMPSITE USE

The Farallon Islands are a chain of small, uninhabited islands located approximately WSW of San Francisco, California. The ocean dumpsite is located south and west of the islands and was actively used from 1946-1962 for the disposal of packaged low-level radioactive wastes. Most of the wastes dumped there were generated by three Atomic Energy Commission (AEC) contractors in California: (1) The U.S. Naval Radiological Defense Laboratory (now defunct), (2) The University of California Lawrence Radiation Laboratory, and (3) The University of California Radiation Laboratory at Berkeley. The radioactive waste disposal operations were carried out by the U.S. Navy until July, 1959 when private companies assumed the responsibility under AEC license. In 1962 the three radiation laboratories changed from ocean dumping to land burial for their radioactive wastes.

1.2 SELECTION OF SURVEY AREA

A perusal of existing disposal records indicated that the actual Farallons dumpsite area was an irregular polygon with an area exceeding 250 square miles. Such an area was far too large to survey under the existing time and budget constraints; therefore, selection of a smaller survey area was mandatory. At this time, March 1974, the Office of Radiation Programs, EPA, requested a fact- finding study to determine if any particular subsite or subsites within the general dumpsite area would be most suitable for a survey. This study (EPA Purchase Order P4-01-03305) involved both a literature survey and personal field contacts. Results of the study are presented in a report to EPA by Interstate Electronics Corporation (Report No. 4550C067).

One of the most important facts emerging from the survey was in an article by M. Waldichuk as contained in the 1960 International Atomic Energy Agency proceedings on Disposal of Radioactive Wastes. Here he states: "The area south of the Farallon Islands, west of San Francisco, has the longest record on the Pacific Coast of receiving radioactive wastes. At the original site, 22 miles from San Francisco in a depth of about 50 fathoms (Site 1 in Figure 1-1), three tug-loads of radioactive wastes were dumped in 1946. Later that year, the dumping location was changed to a point 38 miles west of San Francisco in 1,000 fathoms of water (Site 3 in Figure 1-1). This was used until 1951 when a point 30 miles from San Francisco on the 500-fathom contour (Site 2 in Figure 1-1) was selected for dumping. Since January, 1954 dumping has been resumed at the 1,000-fathom line."

It was now evident that this dumpsite consisted of three distinctly separate sites.

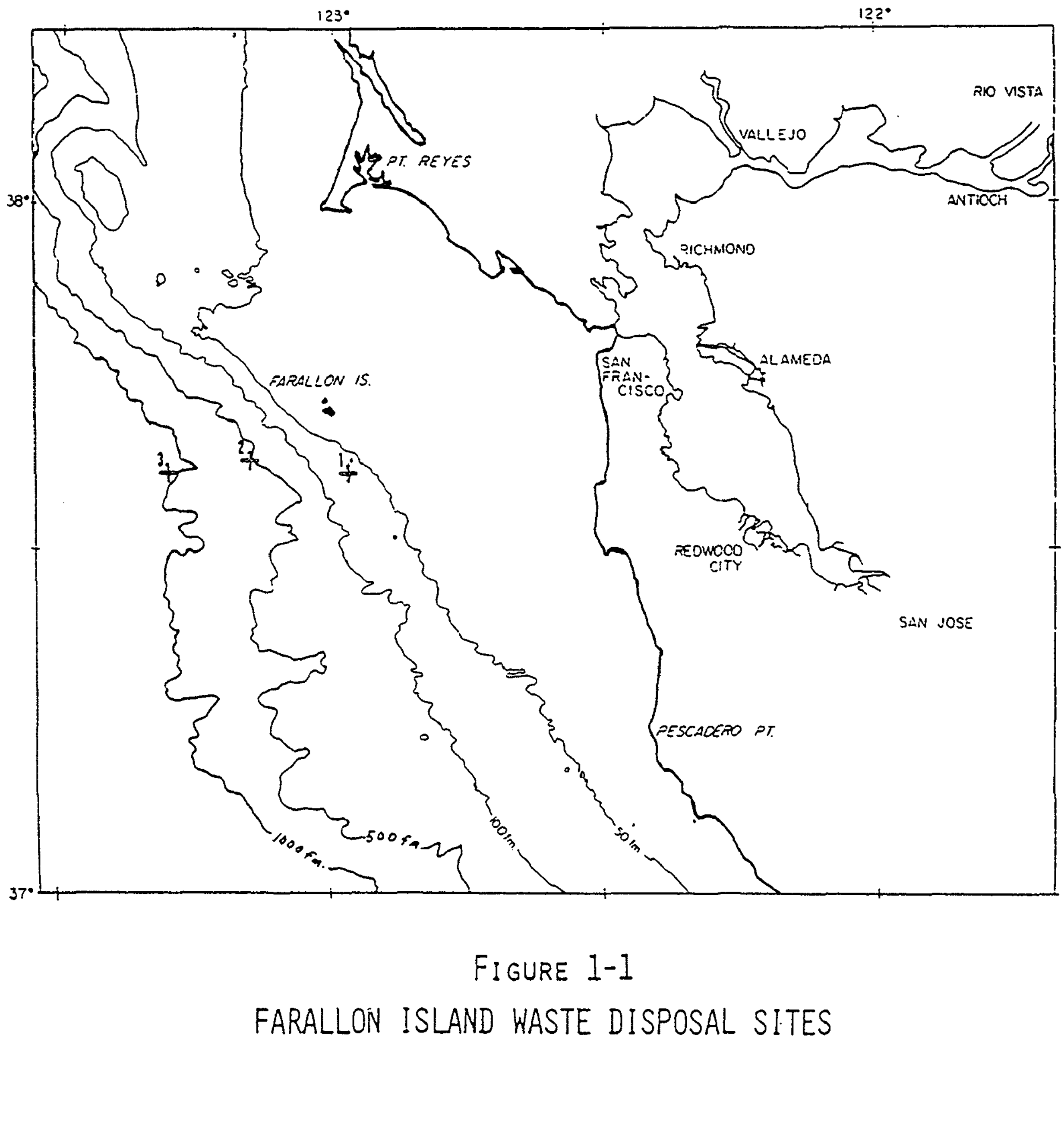

FIGURE 1-1
FARALLON ISLAND WASTE DISPOSAL SITES

Site 2 was selected for this survey after a careful evaluation of four main factors: (1) the inventory of wastes dumped in the site, (2) the characteristics of the radioactive waste packaging, (3) the survey method, and (4) the specific operational objectives.

1.2.1 Waste Inventory

As a result of the previously referenced fact-finding study, it was determined that all of the wastes were containerized and an estimated 150 containers were dumped at Site 1 (depth = 50 fathoms, or 300 feet), 3,600 containers were dumped at Site 2 (500 fathoms), and 44,000 containers were dumped at Site 3 (1,000 fathoms). Only radioactive wastes were dumped at Sites 1 and 2, while Site 3 also received chemical munitions.

1.2.2 Radioactive Waste Packaging Characteristics

Almost all of the wastes dumped were packaged in 55-gallon steel drums into which was poured concrete both for shielding and to insure sinking. In most cases the top of the drum was removed, a concrete bottom cap was poured, the waste was added and surrounded by more poured concrete, and a concrete top cap was added. In a few cases larger concrete vaults were fabricated (5 ft. x 7 ft. x 8 ft.) for larger items of contaminated equipment or slightly higher-activity material.

In November, 1950, the U. S. Navy recommended to Berkeley Radiation Laboratory that the drums of radioactive waste destined for ocean disposal should be equipped with a lifting eye (a cable loop extending out from the concrete cap) made of wire cable or reinforcing bar to permit ease of lifting and maneuvering the drums. By mid-1951 Berkeley had implemented this recommendation and, in turn, this technique was recommended to the Lawrence Radiation Laboratory. By 1952 all packages for ocean disposal were incorporating some form of lifting eye. Thus one of the sites, Site 2, would contain radwaste packages both with and without lifting eyes since the site was used from February 1951 to January 1954. And, in fact, this unique packaging was only used for radioactive wastes. Thus location in Site 2 of a 55-gallon drum with a concrete cap and a lifting eye would positively identify the container as a radioactive waste drum dumped between mid-1951 and January 1954, while the drums without lifting eyes could be even more precisely dated to the first half of 1951. This information would be particularly useful for estimating fouling and corrosion rates of the waste containers.

1.2.3 Survey Method

The Cable-controlled Underwater Recovery Vehicle (CURV III)(Figure 1-2), operated by the U.S. Naval Undersea Center in San Diego, was selected to carry out the survey. It is a tethered, unmanned submersible, is less expensive to operate than

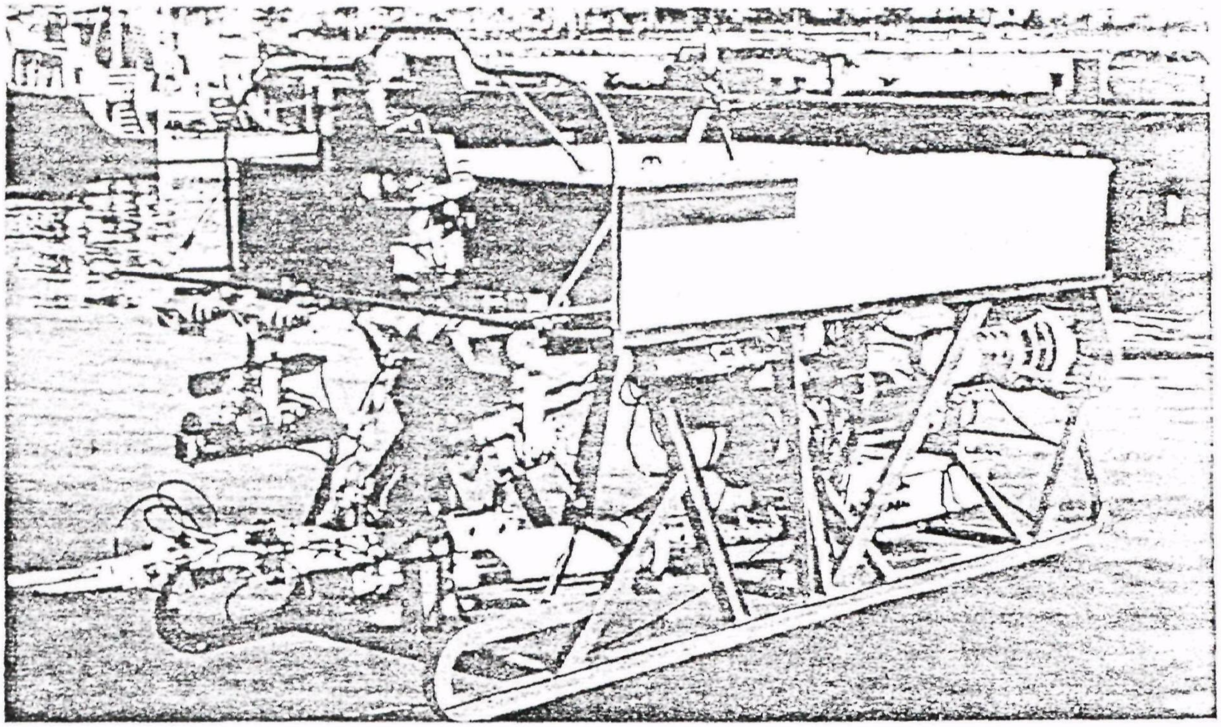

FIGURE 1-2
U.S. NAVY CABLE CONTROLLED UNDERWATER RECOVERY VEHICLE (CURV III)

a manned submersible, and has both sample collection and photographic documentation capabilities. In addition, there is no hazard to operating personnel as no life support system is required and the vehicle is controlled from deckside. Logistically it could be moved to the site with a minimum of time and expense and, most importantly, it could operate to 6000 ft., thus enabling it to survey any of the three dumpsites.

1.2.4 Operation Objectives

(a) Determine the feasibility of a deep-ocean radioactive waste dumpsite survey using a submersible;

(b) Obtain photographic documentation of the condition of the drums including the degree of corrosion and fouling, and assess relative biological abundance,

(c) Obtain precisely-located sediment samples adjacent to both intact and breached containers known to contain radioactive wastes.

In summary, since Site 2 had, (a) precisely known coordinates (37° 39' N, 123° 09'W), (b) wastes of a unique packaging configuration, (c) received enough containers (approximately 3,600) to present a good chance of their being found, (d) received the wastes over a period of time short enough (3 years) to permit dating of observed effects, and (e) was deep enough to be representative of deeper-water conditions without initially testing the submersible system to its operating limits, then the decision was made that an environmental survey operation at this site would most closely fulfill the operation objectives.

1.3 SURVEY CHRONOLOGY

The plan for the actual field investigation at Site 2, the 500-fathom site, was developed in July 1974. The go-ahead for the survey was received on Tuesday, August 13, 1974. The final date available for sailing was Saturday, August 24. This tight schedule resulted in numerous logistic problems all of which were successfully overcome. The U.S. Navy Supervisor of Salvage assigned the M/V Gear (Figure 1-3) to the program. Onloading was completed the night of Friday, August 23, and the M/V Gear sailed from San Diego for the Farallons on Saturday, August 24. Operations on station commenced on Monday, August 26, and were completed on Friday, August 30, 1974.

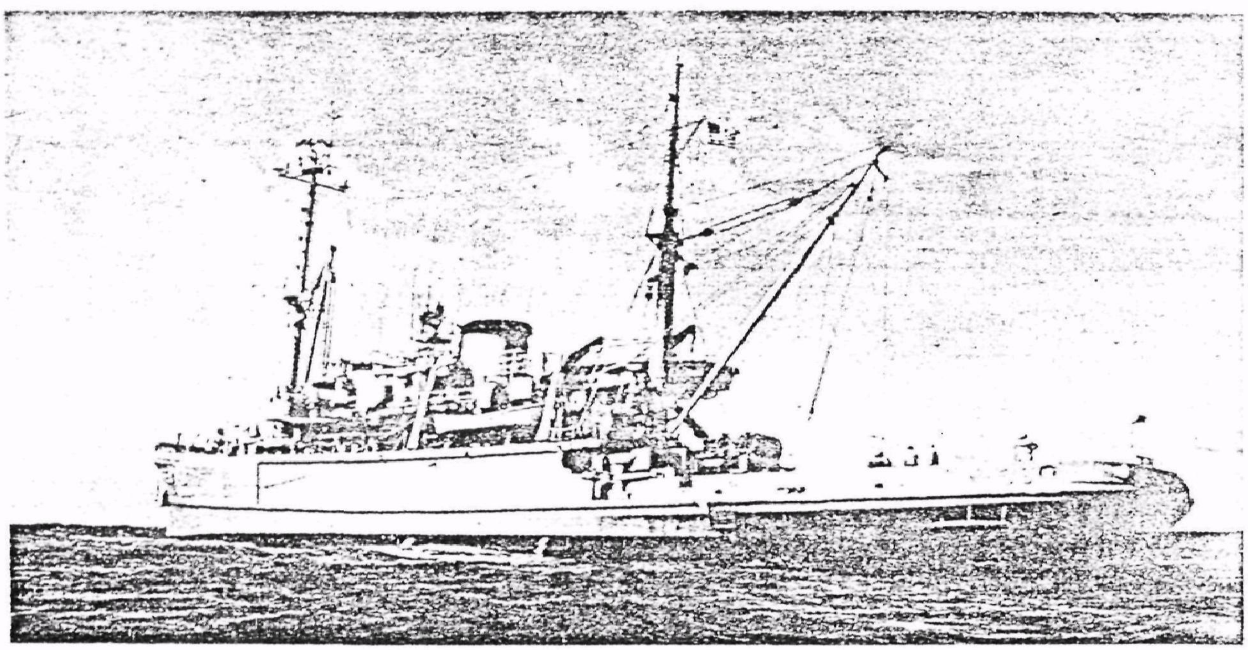

FIGURE 1-3

M/V GEAR

Upon commencement of operation on Monday, August 26, successive predetermined grid locations were investigated, until on Wednesday, August 28, the first major cluster of cannisters was located. Their unique packing configuration (i.e., 55-gallon drums with concrete caps and lifting eyes made of wire cable indicated without a doubt that an actual radwaste disposal site had been reached.

It was originally planned that a final dive would be made at the 1,000-fathom (6,000 foot) disposal iste. However, the time required to adequately sample and photograph the intermediate depth, 500-fathom (3,000 foot) site was such that investigation of the 1,000 fathom site had to be cancelled.

A detailed description of the planning and at-sea operations along with a selection of significant photographs are presented in the subsequent sections.

Section 2

OPERATIONS PLAN

A detailed and comprehensive plan was developed in order to ensure an effective and efficient sea operation. The components of the plan (IEC Document 446-349) are summarized in the following subsections.

2.1 SURVEY AREA

The general survey area was described by NOS Chart 5402 showing the two subareas connected by a traverse zone and their relationship to the Farallon Islands and San Francisco shipping traffic lanes. The first area to be searched was defined as being along the 500-fathom contour line centered at LAT 37°39'N, LONG 123°09'W. The second area to be searched, time permitting, was defined as lying along the 1000-fathom contour near LAT 37°38'N and LONG 123°17'W. Bathymetric charts of the noted area were procured for use in tracking during the search operation.

2.2 PRE-SAILING OPERATIONS

The pre-sailing operations provided definitions for the following important areas:

1. Operation Schedules. - This schedule defined the operational times from mobilization through demobilization as 19 August 1974 to 31 August 1974 with possible extension through 2 September if required.

2. Participant Responsibilities. - The operational responsibilities for each of the participating organizations were defined. These included pre-sailing, as well as sea operation tasks to be completed. The agencies participating in the operation were:

   (a) U. S. Environmental Protection Agency (EPA), participated as lead agency in determination of general operational policy, planning, and funding.

   (b) Interstate Electronics Corporation (IEC), served as mission contractor.

   (c) Murphy-Pacific Marine Salvage Company (M-P), operator of the support ship M/V Gear.

   (d) U. S. Naval Undersea Center (NUC), operator of the Cable-Controlled Underwater Recovery Vehicle (CURV III).

   (e) Offshore Navigation Services (ONS), contractor for precision navigation.

   (f) Environmental Monitoring and Support Laboratory (EMSL), Las Vegas, and EPA-ORP Las Vegas Facility, provided ship board radiation monitoring and analysis.

3. Preparation for Sea Operations. - The preparations for sea operations included factors such as staging areas, ship loading, provisioning, and final boarding schedules.

2.3 SHIP OPERATIONS

Departure and arrival schedules were established for the ports of San Diego and San Francisco. In-transit plans and ship-to-shore communication channels were established.

2.4 SURVEY OPERATIONS

A survey site operational plan was developed and key decision points were introduced with respect to operational delays or termination of the operation. These decision points were a function of impending weather and/or sea-state condition and equipment performance. Details of the operational plan included the following:

1. CURV III Search Operations - describing the pre-established sampling pattern, target identification and verification, photo requirements, sample collection

requirements, course deviation authority, vehicle safety, etc.

2. Grab Sample Operation - describing precise navigation requirements along pre-established track, sampling equipment operation, time requirements, and succeeding sampling procedures.

3. Contingencies - developed principally as a function of impending weather and/or sea-state criteria. Times and points of survey operation were defined and ship and crew safety requirements considered.

Section 3

EQUIPMENT AND INSTRUMENTATION

3.1 CURV III

CURV III (Figure 1-2) is an unmanned, tethered, surface-controlled vehicle as the acronym CURV (Cable Controlled Underwater Recovery Vehicle) readily explains. Physically, CURV is a framework with motors, hydraulic systems and cameras attached. It has syntactic foam blocks mounted to provide balance and a slight, positive buoyancy. Its overall shape resembles a rectangular box. CURV is linked to power and control systems by a multiconductor underwater cable. The weight of the cable over-the-side is borne by a nylon pendant that is periodically tied to the electrical cable. The last 600 feet of cable nearest CURV (the tether) is made neutrally buoyant by attaching blocks of foam. CURV is powered and controlled from the surface and has unlimited bottom-time capabilities. A control console provides visual and sonar maneuvering inputs plus depth and vehicle attitude sensors.

The length of the neutrally buoyant tether is the maximum radius for a search by the vehicle. CURV is powered forward and reverse by port and starboard motors and can be powered up and down by a vertical motor; it is slightly buoyant so it must be powered down to the bottom. CURV is highly maneuverable - both on and above the bottom. A selection of tools (grasping claw, clamshell scoop, hooks, grapnels) provides good adaptability to variable sampling requirements.

CURV has an AMTEK/STRAZA SLAD-603 sonar system that scans an area 120° over a distance up to 800 yards in front of the vehicle. The SLAD (Sonar, Locator, Altimeter, Depthometer) system provides visual (cathode ray tube) and aural signals from a high resolution, rapid scan, continuous transmission frequency modulated sonar system for tracking active or passive targets. The high resolution of the system gives the remote operator the necessary precise location of the target relative to the underwater vehicle. At the same time, the system provides the operators with navigation data that establishes the location of the vehicle with respect to altitude above the ocean floor, and depth below the surface. The sonar display unit on the surface control console provides aural signals and visual displays of target range and bearing, relative to the bow of the underwater vehicle. The CRT sweep displays a 120° sector centered about the vehicle bow.

Limitations of CURV are cable length and weather. Maximum depth of operation is 10,000 ft. with normal depth of operation limited to 7,000 ft. The actual operating depth has not exceeded 5,500 ft to date. Weather limits are about sea-state 4 and are related to launch and recovery dangers.

For documentation purposes and near-bottom navigation, CURV has two television cameras and one 35-mm camera, all remote-controlled from a control van. The television cameras are solid-state vidicon cameras with a water-corrected lens and 54° viewing angle. The 35-mm camera is an EG&G color with 200-watt/sec strobe. Lighting is from 100- or 250-watt pressure-balanced, mercury vapor spotlights.

The initial mode of operation with CURV was a search and traverse method. A pre-established area of greatest probability for locating containers was outlined for a series of traverses. In actual operations, the traverse consisted of a series of searches performed along the desired course with the SLAD 603 sonar system in the following manner:

1. Upon initial setdown of CURV, a sonar search of four quadrants was made to "box the compass". This covered a radius of 800 yards.
2. If no contacts were identified that were considered significant, a traverse in the desired direction, with the sonar on, was made for about 600 to 800 yards.
3. Again a quadrant search was made.

4. If targets within the tether range (600 feet) were located, an immediate investigation was made. If no targets were identified, the traverse continued. Targets out of tether range were approached by moving the ship.
5. Targets of interest that were located by sonar were approached by using the sonar and, if on visual contact were still of interest, the 35-mm camera and the video tape recorder was utilized for documentation purposes.

During the investigation of the dumpsite survey area, cores (3.8 cm. diameter x 48 cm. deep) were taken with an adaption of the manipulator arm. Four cores were available on each dive of the CURV III. The coring configuration utilized by CURV III is shown in Figure 3-1. Each polycarbonate core tube was provided with a one-way finger closure to prevent sediment loss. A Shipek grab had also been mounted on CURV and one grab was available on each dive.

3.2 NAVIGATIONAL SYSTEMS

3.2.1 Mapping and Plotting

Precise positioning of sighted radioactive waste containers was of utmost importance for detailed surveys or subsequent sampling. Preparations to provide precision navigation and bathymetry began

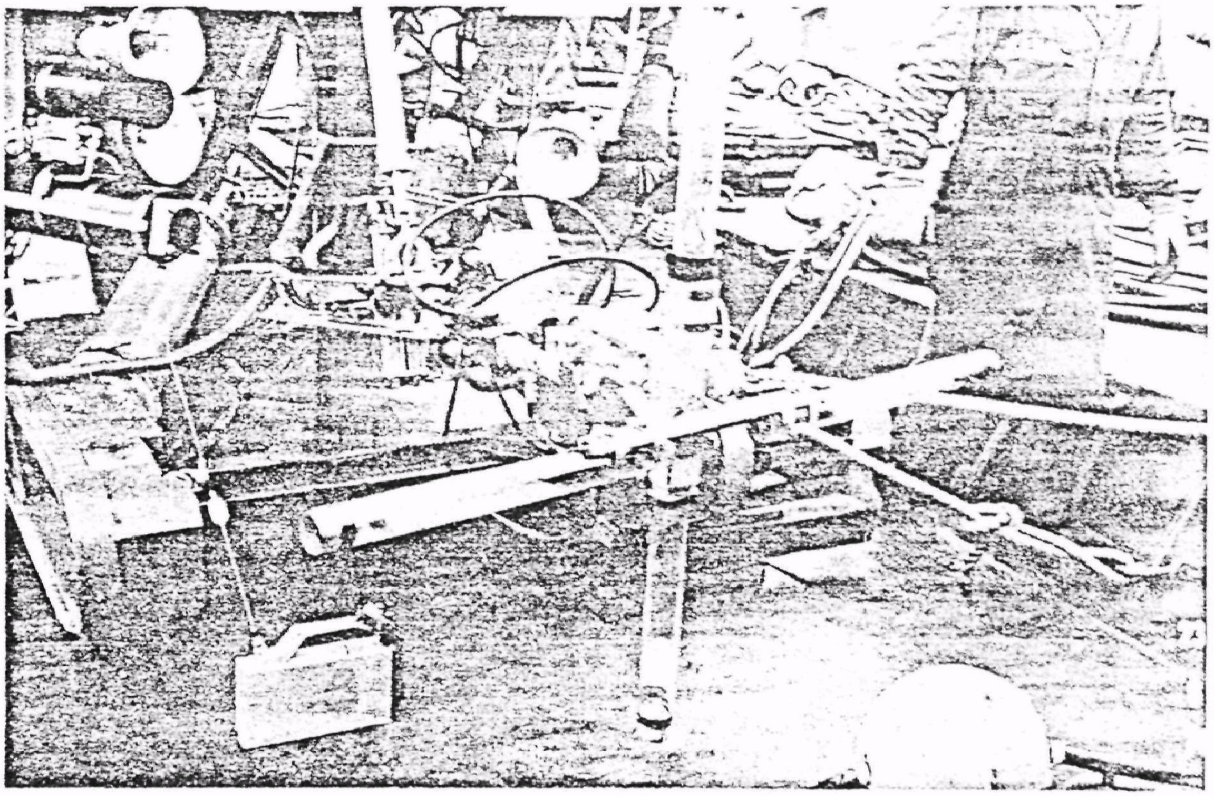

FIGURE 3-1

CURV III CRUCIFORM CORER

with obtaining the best available charts of the area. NOS Chart 5072 - Gulf of the Faralones at a scale of 1:100,000 gave the most detailed coverage, but an inset partially obscures the area and the chart is not fully contoured. NOS Chart 5402 - Point Sur to San Francisco - at a scale of 1:210,668 gives unobscured coverage and is fully contoured at 100-fathom intervals. The best available boat sheets were H-2829, a 1908-1909 survey at a scale of 1:200,000 and H-5472, a 1932 survey at a scale of 1:120,000.

Four mercator grids at a scale of 1:24,000 were pre-plotted covering the area from Lat. 37°35'N to 37°45'N and from Long. 123°00'W to 123°20'W. A fifth grid covering the potential control area from Lat. 37°10'N to 37°15'N and Long. 123°00'W to 123°10'W was also prepared. The contouring from NOS Chart 5402 was photographically enlarged and added to the grids to form the base charts of the area to be surveyed.

Offshore Navigation Services, INC. (ONS), Ventura, California, was retained to provide a Motorola RPS (Radio Positioning System) network for the survey area. The system instrumentation included a Motorola Model III Mini-Ranger and rotary scanning antenna for use aboard the vessel and three transponders located over bench marks at Point Reyes, Mount Tamalpais and Montara Mountain. The Motorola Mini-Ranger digitally displays the range, in meters, from shore transponders and has a probable range error of ±3 meters at 40 nautical miles. Thus providing a highly accurate means of navigation and track plotting.

Because the search pattern to be used during the survey would be dependent upon wind and current direction, precise vessel track lines could not be precalculated. Instead, transponder ranges to 46 points within the survey area and four points within the control area were pre-computed at selected intersections of the one-minute mercator grid lines on the base charts. Also added to the base charts were range arcs from the three transponder stations at intervals of 500 meters.

The resultant plotting and tracking charts are nearly the same as the original plot. The scale of 1:24,000 was changed to 1:25,000 to allow easy measurements using an ordinary metric ruler.

3.2.2 Radio Positioning System

A Motorola Mini-Ranger III positioning system was selected for use both as a primary navigation aid and for positioning during the operation. The prime factor in choosing it was its superiority over more conventional navigation systems. The Motorola Mini-Ranger III is a short-range, pulse radar system. It consists of a range console, two or three shore transponders, rotary scanning antenna, and a receiver/transmitter unit. In operation, the base station, onboard the ship, emits interrogation signals which elicit a reply pulse from two reference stations. The elapsed time from beginning of interrogation to arrival of reply pulses is measured and converted to range data. This data, in meters, is displayed simultaneously on two sets of light emitting diodes mounted in the range console. A precise position of the vessel can be plotted at any instant by this trilateration technique.

The scanning antenna was installed on the M/V Gear above the CURV control van located on the roof of the wheelhouse and connected to the transceiver/display unit placed in the plotting room. Transponders were placed on the bench marks during the weekend of 24-25 August 1974 while the M/V Gear was in transit from San Diego to San Francisco.

Operation was in the 5400 to 5600 mHz band which prevented interference from the ship's radar. The system utilizes pulsed radar type transmissions to determine the distances from the survey vehicle to the reference transponders. The intersection of these range arcs provides a highly accurate fix. Since the information is continually updated, the successive fixes can be used for track plotting. Such is not the case with satellite systems in which the fix is obtained only during the pass. This high-accuracy track plotting feature was the prime reason for selection of this equipment.

3.2.3 Precision Depth Recorder

The precision depth recorder selected was a Hydro Products Model 4000, GDR-IC-19T Gifft recorder. This instrument incorporates a number of features that were particularly desirable for this operation. Basically, it is a complete echosounder with a 1000-watt integral acoustic transceiver. Operating frequency was 12 kHz which permitted use of the ship's standard UQN-type, hull-mounted transducer. A built-in programmer provided the necessary degree of versatility that was required to insure high resolution without interfering artifacts. Recording was done on high resolution, electrosensitive, wet recording paper. Accurate water depths had to be known during CURV operations to determine the correct amount of cable payout. The main cable could not be allowed to drag on bottom, and if it was held too high, the excursion area of the vehicle would be reduced.

3.3 RADIATION MONITORING AND ANALYSIS EQUIPMENT

The objectives of having radiation monitoring and measuring equipment on board was two-fold:

1. Monitoring to detect the presence of any potential harmful radiation in either the samples collected or sampling equipment used in the vicinity of the radioactive waste dumpsites.
2. Measuring equipment to more precisely identify and quantify the specific radionuclides present and provide on-going information to identify sites which might be more thoroughly sampled before returning to shore.

3.3.1 Radiation Survey Instruments (Hand-held)

1. Rank Nucleonics and Controls, Scintillation Ratemeter Type NE-148A. Sodium iodide crystal detector, 1-inch diameter by 1 1/2-inch, with 0-30 microrads/hr, 0-300

microrads/hr, and 0-3 millirads/hr ranges. Two of these instruments were used in the project to survey low-level gamma radiation expected from recovered samples and equipment.

2. Victoreen Instrument Company, AGB-500B-SR "Radector", with wide-range Neher-White ionization chamber rate meter. Instrument has 0.5-500 millirads/hr and 0.5-500 rads/hr logarithmic ranges.

3. Eberline Instrument Corporation, E-500B Geiger Counter. Utilizes an Anton 112 halogen filled GM tube. The instrument has five scales: 0-0.2, 0-2.0, 0-20, 0-200, and 0-2000 millirads/hr, and was used for general beta-gamma surveys.

4. Eberline Instrument Corporation, PAC-ISA Alpha Scintillation Counter. This instrument utilizes a 50 cm^2 scintillation probe and photomultiplier tube and presents a meter reading in counts per minute in four ranges: 0-2,000, 0-20,000, 0-200,000, and 0-2,000,000.

5. Eberline Instrument Corporation, Count Ratemeter, Model PRM-5, battery operated pulse rate meter with single channel pulse height analysis capabilities. This instrument was used in conjunction with a "Fidler" probe to scan for plutonium X-rays. The Fidler probe specifications are: 5-inch diameter by 0.063-inch thick thallium-activated sodium iodide crystal mounted

on a 1.5-inch thick quartz light pipe with a 0.010-inch thick beryllium entrance window and optically coupled to a 5-inch RCA 8055 photomultiplier tube.

6. Eberline Instrument Corporation, Model PG-1 Plutonium Gamma Probe. A 1-mm thick 2-inch diameter sodium iodide crystal with a 0.001-inch thick aluminum window, coupled to a Dumont 6467A photomultiplier tube. This probe is used in conjunction with the PAC-ISA alpha counter described above.

3.3.2 Laboratory Radiation Counting Equipment

1. Nuclear Measurement Corporation, Alpha-Beta-Gamma Proportional Counter, Model PC-3B. An internal gas flow proportional counter with 2 pi geometry used to count small sample aliquots on 2-inch planchets.

2. Technical Measurement Corporation, Model 401D, 400 channel pulse height analyzer system. The analyzer was used in conjunction with a 4x4-inch Harshaw sodium iodide crystal with matched-window integral detector-photomultiplier assembly. The detector-photomultiplier system operates from a 1100 volt D.C. power supply and was placed in a 2-inch thick lead cylindrical shield cavity. It was used to obtain gamma ray spectra from 400-ml sediment sample aliquots counted in right cylindrical polyethylene dishes.

3.4 CONTINGENCY SAMPLING PROGRAM

In the event of a serious CURV malfunction, a backup sampling and *in situ* recording system was assembled. It consisted of: A hydrographic winch equipped with 10,000 ft. of 1/4" hydrographic wire; an InterOcean 550 STD recorder; an InterOcean B-1055 pinger (12 KHz), and a Shipek grab sampler.

The winch was a "Bendix Deep-Sea Winch" with capacity for 23,000 feet of 1/4" wire rope. The wire was U.S. Steel 1/4" galvanized 3x19 torque-balanced wire rope. The STD incorporated internal recording, battery-powered system from InterOcean Systems, Inc. It had an optional dissolved-oxygen sensor and measured conductivity, temperature, depth and DO, two parameters (C, T) on the down cast and one (DO) on the upcast, all plotted versus depth. The 12 KHz pinger matched the UQN-1 ship fathometer transducer. It was used to monitor the height off the bottom of the instrument packages and equipment.

The Shipek grab sampler was a Hydro Products Model 860, identical to the one used on the CURV III. The sample is approximately 60 square centimeters in surface by 14 centimeters deep at the center. It is particularly well adapted for pickup of benthos organisms living at or immediately below the sediment-water interface.

The instruments were arrayed on the wire in the following fashion: First, the Shipek sampler; then the STD profiler 10 meters above followed by the pinger one meter above the STD profiler. This arrangement prevents the STD from touching the bottom. The pinger was to be tracked on the depth recorder which allowed lowering rate to be slowed to 1/2 ft/sec at a distance 100 meters from the bottom and then stopped at 5 meters from the bottom.

The package was deployed on August 26 after a CURV malfunction. Contact with the pinger was lost near the bottom, and when reestablished, it appeared that the package did touch bottom. The Shipek successfully collected a sample, but the STD profiler had malfunctioned and no water column data was collected.

3.5 MALFUNCTION OF THE STD/DO PROFILER

Prior to launching, the Model 550 profiler was checked out and was operating. Upon recovery, it was found that the profiler had failed. An IEC electronic engineer and an electronic technician of the Environmental Protection Agency checked out the unit onboard the ship to determine the cause of failure. The first problem uncovered was that the pen assemblies had not dropped onto the chart paper, although the pen lifters had been placed in the down position. It was determined that friction within the mechanism was such that the pens would not drop in place unless an upward pull was given on the pen lifter knob. Since the chart recording assembly is not visible without removing the pressure housing, there is no positive way of knowing if the pens are in position. The next fault was indicated by improper readings at the test points on the voltage regulator card. Visual inspection revealed a cold solder joint which had fallen off of a printed circuit board connector. Resoldering of this wire reestablished correct readings at the test points on the voltage regulator board. Inspection of the plug-in boards indicated components improperly mounted. Specific examples included clusters of capacitors whose leads were twisted together and stuffed into integrated circuit sockets. Although replacement of the power supply lead resulted in proper voltages on the voltage regulator board the unit was still not fully operational. Further visual inspection revealed the cause. Leads going to the servo amplifier boards were improperly dressed. Mechanical design was such that there was no way to prevent abrasion when the pressure-proof housing was removed and replaced as is necessary during normal test and operations. Inspection revealed that abrasion had, indeed, been the problem, and that the insulation on the twisted wiring had been worn off completely in several places. This had resulted in a short circuit destroying one of the semi-conductors. Since no spares were provided with the unit, it was impossible to repair it in the field.

No moisture entered the unit during the cast. However, the necessity for opening the unit on deck to turn the power on and drop the pens allows moist warm air to enter the unit. During deployment, external temperatures in the range of 4°C are normally encountered resulting in condensation of moisture on the circuit board contacts and electronic components.

Section 4

SURVEY CONDUCT

4.1 OPERATIONS LOG

The following summary of the Operations Log provides an outline of the general chronology of the survey including: the daily routine; normal and special operations; the time required to perform the various tasks; the areas covered by the survey; some on-site observations and operational problems encountered. It will be noted that the basic schedule in the Operation Plan of Section 2 was maintained except for surveying of the control site. The allotted time was used to make additional observations at the 500 fathom disposal site. Under operating conditions, some details of the Operation Plan were deemed not to be feasible; these included multiple dives per day and bottom traversing between planned sampling stations. All courses mentioned in this log are referenced to true north. A brief coordinate map showing the relative position of each survey station is provided as Figure 4-1.

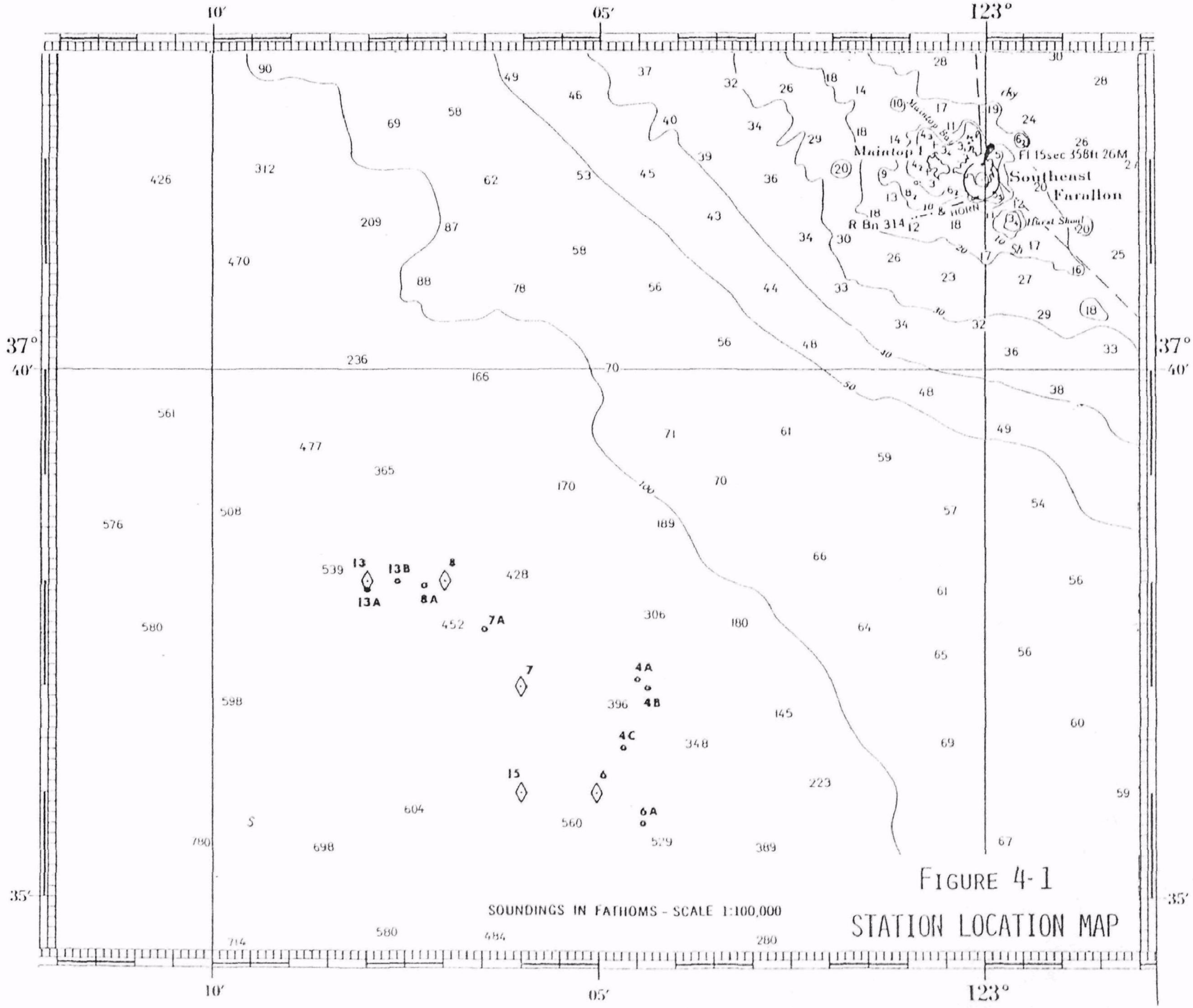

FIGURE 4-1

STATION LOCATION MAP

OPERATIONS LOG

8/23/74	0800	Start loading of M/V Gear at NUC dock.
	1300	ONS loading and checkout complete.
	1730	EPA loading and checkout complete.
	1930	IEC loading and checkout complete.
	2000	NUC loading and checkout complete.
	2100	All equipment secured for transit.
8/24/74	0600	Depart NUC dock, San Diego.
	0800	Recover and relocate NUC spar buoy.
	0900	Resume transit to San Francisco.
8/25/74		In transit.
8/26/74	0500	Arrive Embarcadero and launch shore boat.
	0630	Final loading complete. Depart for disposal area.
	0948	Begin drift determination.
	1030	Conclude drift check. Wait for weather report.
	1245	Start CURV launch procedure for Station 4.
	1310	Ship on station.
	1316	CURV in water.

	1321	Begin descent. Station 4 depth approximately 640 meters. Site approx. 1000 distant meters on 145° heading.
	1325	Vehicle traversing at 150 meter depth toward Station 4 site.
	1350	Electrical short on 110V line, current excessive - over 2 amps.
	1353	Begin recovery of vehicle.
	1410	CURV on surface.
	1430	CURV on deck. Troubleshooting the problem.
	1700	CURV no-go. Run profile/grab at Station 6.
	1755	Shipek sediment grab #1 taken at Station 6A. Depth 914 meters.
	1850	Grab up. Return to Station 4.
	1900	Secure operations. Profile recorder failed. Sediment sample is medium olive-gray clay, slightly silty, containing empty 1-pint whiskey bottle, broken glass, small vial, fish vertebrae, worm tubes, and mollusk shells.
	1930	CURV repairs complete. Replaced bad connector and honed the pitted O-ring surface.
8/27/74	0800	CURV on-deck check complete.

0808	Start drift check.
0840	End check. To launch area Station 4.
0855	On site.
0900	CURV in water.
0915	Station 4 in depth of approximately 640 m. at a distance of 900 meters on 190° course.
0920	Start descent.
0940	Vehicle traversing at depth of 275 m. towards Station 4, which is at a distance of 1200 m. on course 238°.
1005	On bottom at Station 4A. Targets on heading 000° at 100 yds.
1016	Sonar scanning. No targets of significance.
1032	Two fish photos. Bottom temperature 10° C.
1040	Five-gallon (?) container observed.
1100	At Station 4B. Begin traverse to Station 4C.
1207	Main circuit breaker in control shack popped - reset.
1215	Stop and scan at Station 4C.
1245	Exploring ravine slope 18-20 degrees. Depth 762 meters.
1315	Continue to Station 6. Course 225 degrees.
1411	At Station 6 and holding. Depth 945 meters. Explored several targets. None of interest.

	1625	On to Station 15, bearing 270° for 1400 meters.
	1650	Stop and hold. Close on possible target. No interest.
	1725	On to Station 15.
	1810	Holding position. Russian trawler sitting over next Station (15). Weather beginning to worsen.
	1944	At Station 15 and holding. Depth 929 meters.
	2015	Ship requires 20 turns to hold station. Exploring targets.
	2123	Took two cores and one grab. No targets of interest.
	2130	Start retrieval from 975 meters. Temperature 6° C.
	2303	CURV on surface.
	2325	Secure operations.
8/28/74	0600	Start drift check.
	0645	CURV on-deck check complete.
	0730	End drift check.
	0735	To Station 7 launch point.
	0845	Launch CURV. Vehicle bumped rail on launch. Sea state 3-4.

0950 On bottom and scanning. Depth 840 meters, 15° slope.

1010 To Station 8, at a heading of 000 degrees.

1110 Stop and scan at Station 7A. No targets.

1132 On to Station 8. Bearing 000 degrees for 900 meters.

1327 On Station 8 and scanning.

1350 On to Station 13. No targets at Station 8.

1410 Stop at 8A. Target?

1435 On to Station 13. (8A was false alarm.)

1530 <u>Many 55-gallon drums sighted slightly south of Station 13 (=13A), and grouped in an area approximately 30 meters by 100 meters.</u>

1535 At Station 13A, going to detail mode. Depth 913 meters. (NOTE: CURV has capability to collect four cores and one grab sample per dive.)

1540 Collected core sample near concrete-capped end of drum. Documented sample collection with videotape and 35-mm colverage.

1606 Fix requested - Station 13A. Coordinates: 37°37'57.2"N, 123°08'00.8"W. Temperature of water 6° C.

1650 Investigated cluster of drums, 30 m. x 60 m. containing 28 distinct sonar targets (drums).

	1705	Took core near center-crushed drum lying on side.
	1720	Approaching another drum cluster containing approximately 100 drums in an area about 130 m. x 250 m.
	1747	Cable caught on anchor. Cannot hold position. CURV dragged 150 meters south.
	1815	Returning to the large cluster of drums at Station 13A.
	1855	At Station 13A.
	1905	Core taken near drum imploded in center
	1915	Core taken in middle of tight cluster of drums.
	1920	Shipek grab taken at end of badly crushed drum.
	2050	CURV on surface.
	2110	CURV on deck.
	2115	Secure operations.
	2330	Discovered 35-mm camera malfunction (no film advance), cause probably due to rough launching.
8/29/74	0650	Start drift check.
	0715	CURV pre-dive checkout complete.

0740	End drift check. To Station 13A launch point.
0925	At launch point. Sea state 4; wind from NW at 18-20 knots. Marginal launch conditions.
0930	CURV in water.
1050	CURV on bottom. Drums in sight. Picked up end of one barrel with manipulator. Rolled several others over to inspect extent of corrosion.
1130	Water temperature 8° C.
1145	CURV pulled off station by ship.
1220	Back on station. Resumed operation.
1245	Lost holding position. Depth 855 meters.
1350	New group of drums sighted ENE of Station 13A (=13B) in a 30 m. x 30 m. grouping. Ship unable to retain heading due to interference with CURV III cable.
1610	Resumed position at Station 13B. Holding. Depth 860 meters.
1730	Lost holding position.
1815	Start recovery of CURV.
1925	CURV on surface.
1940	CURV on deck.
2054	Start bathymetric survey of area between Stations 13 and 9.

	2340	End bathymetric survey.
	2345	Secure operations.
8/30/74	0630	Start drift check.
	0700	CURV on-deck check complete.
	0735	End drift check. To Station 13B launch point. Sea state 4; wind from north at 15-17 knots; wave height 4-6 ft.
	0845	CURV in water.
	0910	Surface water temperature 17° C.
	1045	CURV on bottom. Depth 839 meters.
	1052	Drums sighted.
	1055	Fix requested. Station 13B coordinates: 37°38'02.4"N, 123°07'32.9"W.
	1120	CURV pulled off station due to M/V Gear station-keeping problems.
	1225	Back on station. Investigating individual drums.
	1235	Shipek grab sample taken.
	1245	Vertical and starboard motors (CURV) trip circuit breakers when at full throttle. Begin recovery.
	1350	CURV on surface. Vehicle dead in water. (Low voltage AC short.)
	1405	CURV on deck, begin repair of CURV.

	1415	Secure operations. Return to San Francisco as scheduled.
	1730	Launch shore boat and offload personnel.
	1800	Proceed to Oakland Naval Supply Center.
8/31/74	0800	Start equipment offloading at Oakland.
	0900	CURV vehicle repaired.
	1000	Complete light equipment offloading. Heavy equipment offloading to be in San Diego after completion of follow-on CURV operation for the Corps of Engineers.
9/9/74		Final offloading at San Diego. End of survey operations.

4.2 Ship's Positioning

During the hours from 0000 to 0600, M/V Gear maintained steerage way by slowly cruising up and down wind in an area off the Farallon Islands, avoiding the major San Francisco shipping lanes. During these early morning hours, the ship was navigated using radar ranges and bearings from the nearby islands. Accuracy of positioning to within 1/2 mile was easily obtainable.

During the usual operating hours of the day, from 0600 until CURV recovery was started, all positioning was done by precision fixes using the Motorola RPS system, usually at five-minute intervals. All precision fixes were logged and plotted in the following manner:

1. As the sweep-second hand of the ship's chronometer passed "0", the event marker of the Gifft recorder and the "Hold" button of the Mini-Ranger were pressed.
2. The time and depth in meters were annotated on the fathogram and the time and two ranges entered on the daily position log sheet. The two ranges normally used were from Point Reyes and from Mount Tamalpais, known as "Head" and "Ridge". These were being updated every few seconds, whereas responses from the transponder on Montara Mountain frequency required 10 to 15 seconds. The Mini-Ranger "Hold" button was released after logging the two digital readouts.
3. The fix was then plotted on the base chart by manually scaling from the nearest range arcs. The scale was marked in 100-meter graduations that were spaced 4.16 mm apart (1:24,000). Even coarse pencil lines and points (1 mm) gave a resolution of ±15 meters and careful work would give a resolution within 10 meters.
4. To avoid cluttering up the base chart, most of the tracking points were periodically erased except for those with special significance. All or any portion of the ship's tracks may be replotted from the log.

After CURV recovery had started, the fathometer was shut down and logging of the fixes stopped. However, the RPS was kept on and continuously monitored in the event that the CURV lifting line and cable parted and the vehicle lost its positive buoyancy. Thus, its precise location would be known for subsequent recovery.

4.3 Bathymetry

The Gifft recorder was operated approximately through the same period as the RPS logging. For the depth range of 700 to 1000 meters over most of the surveyed area, the most convenient full-scale range was 300 meters (1.5 mm = 1 m) with depth graduations at 20-meter intervals. Thus, depths to within five meters could be read with a quick glance, to within two meters with normal "eye balling" and within one meter using multiple dividers. The best trace, during CURV operations, was obtained using a gating program of three transmitting pulses followed by three receive/write pulses at a gain of 10. Gains of 20 to 100 were required when the ship was backing or during the special bathymetric survey when the ship's speed was five knots. A paper feed rate of 2 cm per minute was adequate for resolution even over the rough bottom at the five-knot survey speed. During the one-to-two knot transit speeds and station keeping periods, this feed rate was maintained. Trying to save paper by slowing the feed rate caused the wet process paper to dry out under the moving stylus and wrinkling resulted.

As could be expected, the contouring on the published charts was highly generalized compared to what may be plotted at a scale of 1:25,000. For example, the 500-fathom survey area is shown on NOS Chart 5402 as a very broadly rounded nose, gently plunging to the west between two intermediate-sized sea-valleys. Because it was shown to be one of the smoothest areas on the upper continental slope of central California, no problems were anticipated in making CURV transits or operating the sonar in any direction desired. This area actually is a series of ridges and gullies with slopes up to 30° and numerous ledges and mounds with local relief exceeding 40 meters. A special bathymetric chart, at a scale of 1:10,417, with a contour interval of 10 meters, was prepared from the bathymetric and navigational data. This chart is presented as Figure 4-2.

4.4 Drift Determinations

The first phase of the daily operation was to determine drift rate and direction of the ship. This was done because during the launching of CURV, the M/V Gear must not turn its screws for a period of five to fifteen minutes while CURV is driven around the stern and up to the bow of the ship. The drift rate and direction was determined by plotting a series of precision fixes

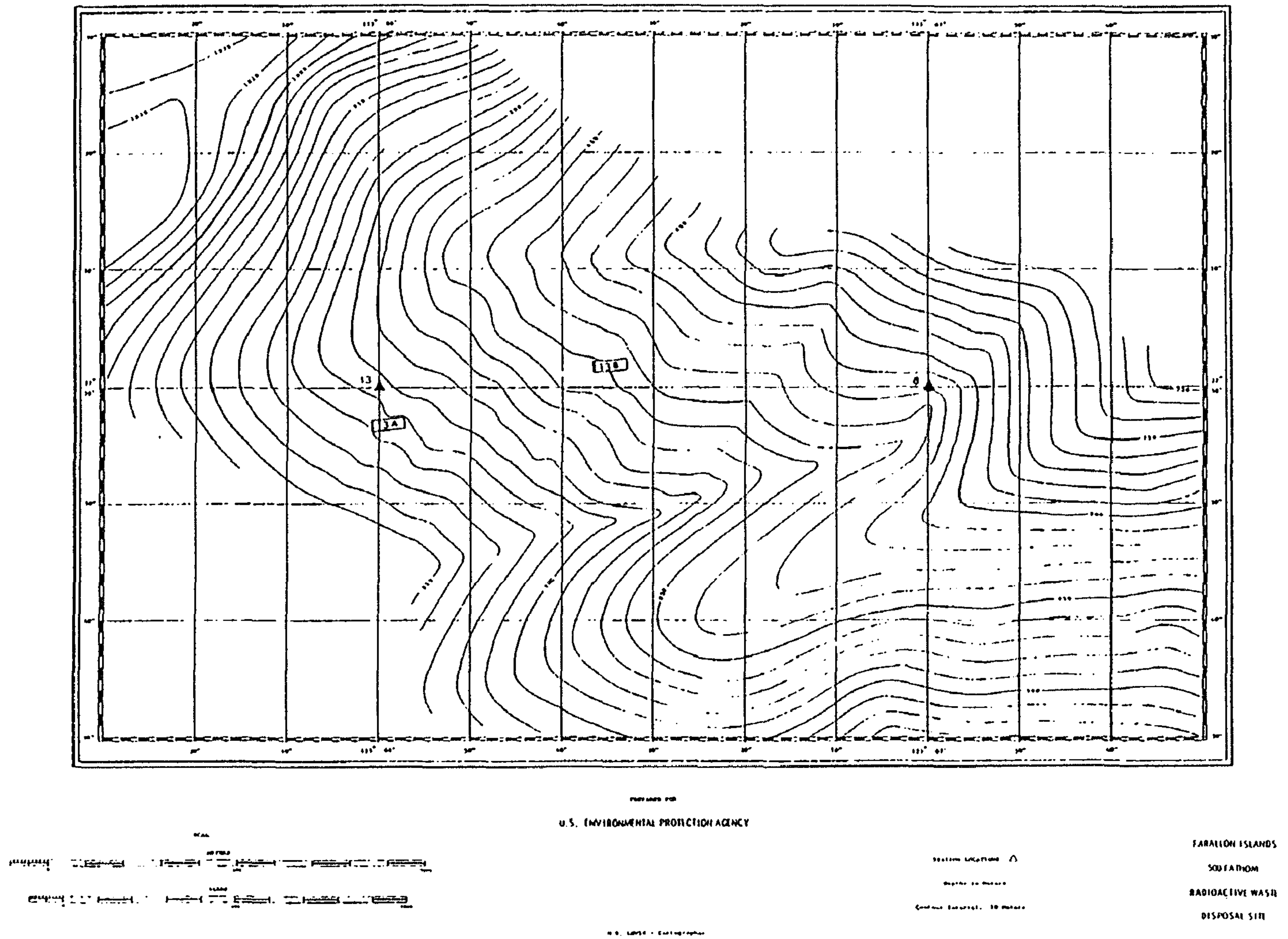

FIGURE 4-2
SPECIAL BATHYMETRIC CHART

at five-minute intervals for a period of one-half hour or more, with the ship lying dead in the water. During the survey period, the drift ranged from 0.5 to 1.0 knots and was generally to the southeast. With this information, a launch point was established fifteen minutes updrift of the selected bottom target site.

In future launches of the CURV from M/V Gear, this procedure of obtaining drift rate and direction, and determining a launch point updrift from the target point may be minimized because of the following factors:

1. The CURV vehicle and its cable act as a sea anchor after launching and the drift rate is approximately half that of the ship alone.
2. The ship is headed into the wind and sea at the start of the launch and several minutes elapse before it falls off and lays broadside to the wind. Thus, the full effect of the wind is not felt during this interval.

Section 5

SHIPBOARD RADIOANALYSIS

The EPA Office of Radiation Programs --Las Vegas Facility (ORP-LVF) and the Environmental Monitoring and Support Laboratory, Las Vegas (EMSL-LV) provided shipboard radiation monitoring and measuring services. These included radiation monitoring of the CURV and associated equipment upon recovery from each dive and counting of sediment samples for radioactivity.

Personnel radiation dosimeters were provided for all personnel involved with handling the CURV who could conceivably be exposed to radiation from recovered samples. Conventional beta-gamma film dosimeters were provided by NUC for the deck crews and a thermoluminescent dosimeter (TLD), provided by EPA, was worn by the Murphy Pacific diver. No personnel radiation exposures above expected background were recorded for any individual on the project.

The radiation monitoring and counting equipment carried on the M/V Gear for the project are described in Section 3.3 of this report. Figure 5-1 illustrates the temporary laboratory which was installed in the ship's carpentry shop.

Four-hundred milliliter aliquots were taken from one core sample and from all four Shipek grab sediment samples. These were counted for 100 minutes each in the gamma spectrometer system described in Section 3. Analysis of the gamma ray spectra did not reveal the presence of man-made radionuclides in any of the counted samples within the detection limits of the counting system. Naturally occurring potassium-40 and radionuclides of the uranium and thorium decay series were detected. A complete inventory of samples collected during the survey is presented in table 5-1.

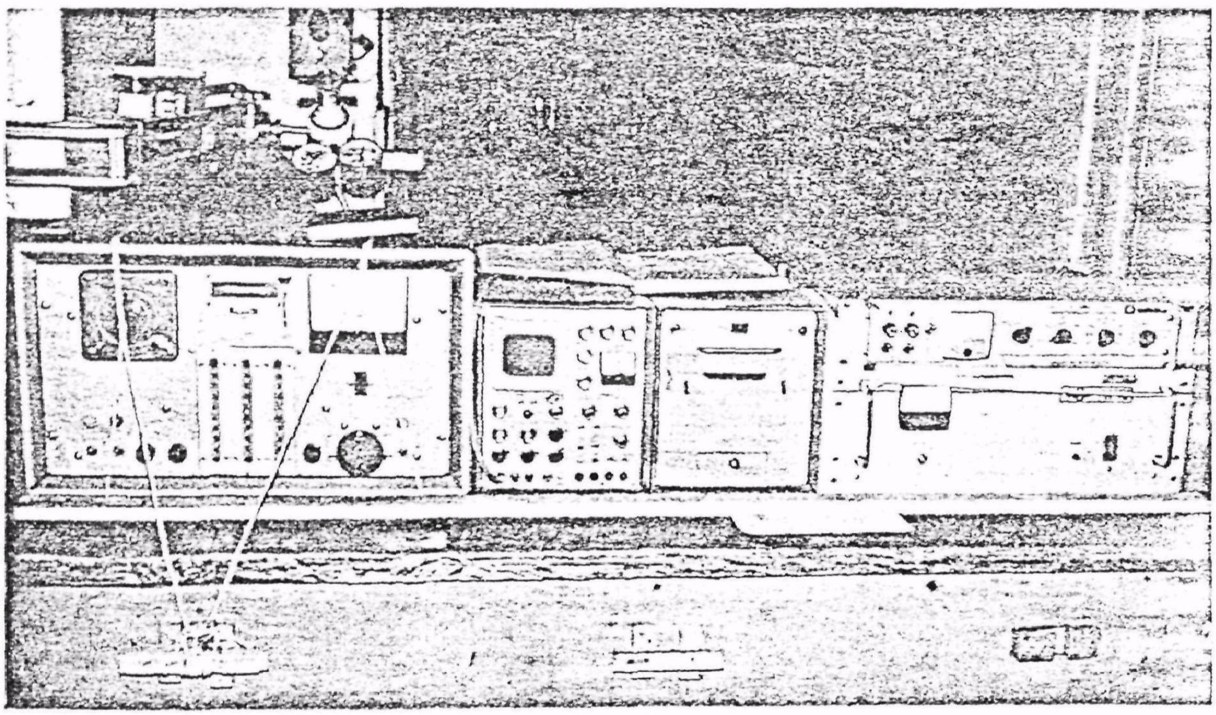

FIGURE 5-1

TEMPORARY LABORATORY ABOARD THE M/V GEAR

TABLE 5-1

FARALLON RADIOACTIVE WASTE DISPOSAL SITE STUDY

AUGUST 26-30, 1974

SAMPLE INVENTORY-SEDIMENT AND BIOTA

NERC-LV Sample Number	Date Collected	Sample Identification	
16-134268	8-30-74	Sta. 13B	Sponge
16-134269	8-27-74	Sta. 15	Core 1 (1/2 full)[1]
16-134270	8-27-74	Sta. 15	Core 2 (2/3 full)
16-134271	8-28-74	Sta. 13A	Core 1 (2/3 full)
16-134272	8-28-74	Sta. 13A	Core 2 (2/3 full)
16-134273	8-28-74	Sta. 13A	Core 3 (full)
16-134274	8-28-74	Sta. 13A	Core 4 (2/3 full)
16-134275	8-26-74	Sta. 6A	Shipek Grab
16-134276	8-27-74	Sta. 15	Shipek Grab
16-134277	8-28-74	Sta. 13A	Shipek Grab
16-134278[2]	8-30-74	Sta. 13B	Shipek Grab
16-134279	8-26-74	Sta. 6A	Grab, 400 ml Aliquot[3]
16-134280	8-27-74	Sta. 15	Grab, 400 ml Aliquot[3]
16-134281	8-27-74	Sta. 15	Core 3, 400 ml[3] [4]
16-134282	8-28-74	Sta. 13	Grab, 400 ml Aliquot[3]

[1] All core tubes were 3.8 cm. diameter x 48 cm. deep.

[2] Sample 16-134278 was mostly water; the Shipek grab may have triggered while only partly in contact with the sediment as the sample was obtained during station-keeping difficulties CURV experienced just prior to last dive termination.

[3] Counted in gamma spectrometer system (4" x 4" NaI) aboard M/V Gear.

[4] This represents the entire volume of Station 15, Core 3.

Section 6

SEDIMENT CONTROL SAMPLES

Control samples were obtained through correspondence with the following Pacific coast schools and universities: Humboldt State University, Oregon State University, Scripps Institution of Oceanography, U.S. Naval Postgraduate School, University of Southern California, and the University of Washington. To the extent practicable, certain criteria were adhered to in the selection of samples; viz., collected near 1000 m contour, mass of 500-1000 grams and representing relatively undisturbed surface sediment where possible.

Difficulties encountered obtaining samples meeting these criteria warrant some discussion. Standardization of collection depth from sample to sample was impossible; also, samples at depths as great as 1000 meters were not generally available. Apparently, this stems from the large quantity of material requested (most universities only retain small quantities of each sample they collect), and the significant academic interest in the continental shelf and continental slope. Variance in sampling devices caused differences in sediment quality (e.g., grab samples are more susceptible to sediment wash-out than box cores).

Although this method of gathering control samples presented many problems, it was the best system employable under existing time and financial constraints.

The following is a list of the control samples obtained.

SEDIMENT CONTROL SAMPLES - FARALLON SURVEY

26-30 AUGUST 1974

Core GC-04B	University of Washington: Cruise TT-022, Station 004; collected 11/11/67; 115 cm in length; one sample (0-12 cm); depth - 902 meters; location - 47°28.9'N, 125°15.7'W; description - clay.
Core 6708-38	Oregon State University: 472 cm in length; two samples (0-45 cm and 46-90 cm); depth - 988 meters; collected 8/21/67; location - 42°35.2'N, 124°50.4'W; description - silty clay.

Grab	U.S. Naval Postgraduate School: Shipek grab sample specially collected on 9/13/74; depth - 229 meters; location - 36°40'N, 122°01'W; description - coarse to medium sand. Came in two pockets: 1) 946g dry wt, 2) 33g wet wt.
Grab TO-31	Humboldt State University: Smith-McIntyre grab sample (2); depth - 366 meters collected 10/14/72; location - 40°47'N, 124°30'W; description - sandy clayey silt. Size analysis 11% sand, 62% silt, 27% clay.
Grab TO-62	Humboldt State University: Smith-McIntyre grab sample (2); depth - 366 meters; collected 11/17/73; location - 40°59.5'N, 124°25.5'W; description - silty clay to clayey silt.
Box Core 20693	University of Southern California: Two samples (0-4 cm and 25-30 cm); depth - 294 meters, collected 7/26/74 in Hueneme area; location 34°02'15"N, 119°04'W (2.4 miles @ 007.5° true to Point Mugu); description - clayey silt.

Box Core 20283	University of Southern California: One sample (0-4 cm); depth - 73 meters; collected 2/27/74 in northern Channel Island area; location - 34°05'54"N, 120°16'W (4.0 miles @ 235° true to northeast corner of Prince Island); description - sandy silt containing small shell fragments.
Core LC-1	Scripps Institute of Oceanography: One sample (0-110 cm); depth - 899 meters; collected 9/16/59; location - 32°48.85'N, 117°34.0'W (taken on La Jolla Canyon Fan); description - silty sand containing small shell fragments.

Section 7

PHOTOGRAPHIC DOCUMENTATION

All of the following photographs were taken at a depth of approximately 900 meters, and all but the last two photos were taken with a 35-mm EG&G underwater camera.

Frame 357 — Fifty-five gallon radioactive waste barrel showing a moderate amount of hydrostatic crushing. A wire lifting eye is protruding from the concrete cap at the left end of the barrel. A deepsea sole, _Embassichythys bathybius_, is occupying the upper indented area.

Frame 364 — This barrel was lifted by the manipulator arm of CURV III to show the limited extent of barrel penetration into the sediment. The sediment under the barrel shows black bands that may indicate anoxic corrosion of that part of the barrel in direct contact with the sediment.

Frame 367 — Another example of hydrostatic crushing at the center of a barrel, a common phenomenon in this dumpsite. A long lifting eye of wire rope is visible protruding from the concrete cap at the right end of the barrel. The CURV III manipulator and its hydraulic hose system are in the left foreground.

Frame 372 Closeup view of the concrete cap in a typical radwaste barrel at this site. These concrete caps were generally about 20 cm to 30 cm thick at both ends of the barrel. CURV III manipulator hydraulic hoses are in the foreground.

Frame 374 Barrel in foreground shows effect of hydrostatic pressure in warping the length of the barrel. An anemone is attached to the concrete cap. Another barrel with a lifting eye is seen in the background.

Frame 379 View of underside of barrel that was rolled over. Good view of lifting eye in the concrete cap. Black deposits (sulfides) typical of anoxic corrosion are visible and appear to start a short distance below the sediment surface.

Frame 388 A barrel with no evidence of hydrostatic crushing. A coating of fine, minimally disturbed sediments is prominent on the upper area of the barrel indicating the relatively small amount of sediment deposited since disposal 22 to 24 years ago. The metal cap (bottom) end of the barrel is at the lower right of the photo.

Frame 403 — Closeup view of a lifting eye on a barrel. This barrel's concrete cap is recessed inside the barrel end as contrasted to Frame 357 where the concrete bulges above the rim of the barrel.[1] Note barrel immediately adjacent in background, also flatfish partly visible beneath sediment cloud.

Frame 404 — View of upper surface of barrel shown in Frame 403. This barrel is imploded and may have been breached as evidenced by the sharp edges of the crushed area. TV viewing also indicated this. A photograph of this crushed area, taken from the poorer quality videotape record, is shown in the TV 2 photo; the angle of the photograph is different from Frame 404.

Frame 409 — Upright barrel showing large vase sponge attached to barrel. This sponge is of the Class Hexactinellida and probably represents a new genus.[2]

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1 On March 12, 1954 the U.S. Navy stated that henceforth all 55-gallon drums containing radioactive waste must have concrete caps recessed at least 1-1/2 inches to permit loading and handling by chime hooks.

2 Toxonomy completed by Dr. Gerald Bakus, University of Southern California.

Frame 410 This photo shows the type of clustering of barrels that was typical of the sites. Three barrels are in the field of the camera (camera range was about 12 feet). This clustering supports the fact that the barrels were all released at one time from a hopper-type barge rather than being dumped individually over the side.

Frame 413 Fifty-five-gallon drum viewed from the bottom end (metal cap). A thornyhead fish, either Sebastolobus alascanus (short-spined) or Sebastolobus altivelis (long-spined), and a tanner crab, Chionoecetes tanneri, are visible near the barrel end.

Frame 415 An example of the extensive hydrostatic crushing some barrels exhibited.. Implosion of most barrels was in the center third as shown here.

Frame 484 Barrel with atypical crushing at the concrete cap end. It would appear that the waste, containing air voids, was packaged without an adequate concrete plug at this end.

Frame 486 Undecipherable lettering is visible on this end-crushed barrel. Two Sebastolobus are at the left front of the barrel. Two anemones on an unidentified substrate are immediately in front of the barrel.

Frame 487 Closeup of the 55-gallon drum shown in Frame 486. A poor-resolution print from a videotape closeup of this same drum is shown in TV 1.

Frame 492 Example of the typical implosion pattern of the many barrels sighted. This implosion pattern corresponds to those from laboratory and field experiments on test containers at the similar pressures and depths. (Pneumodynamics Corp.; 1961; Pearce, et al; 1963.) The crushed portion is a series of regular indentations with a slight twist in the longitudinal axis. A closed cylinder under high external hydrostatic pressure would collapse similarly.

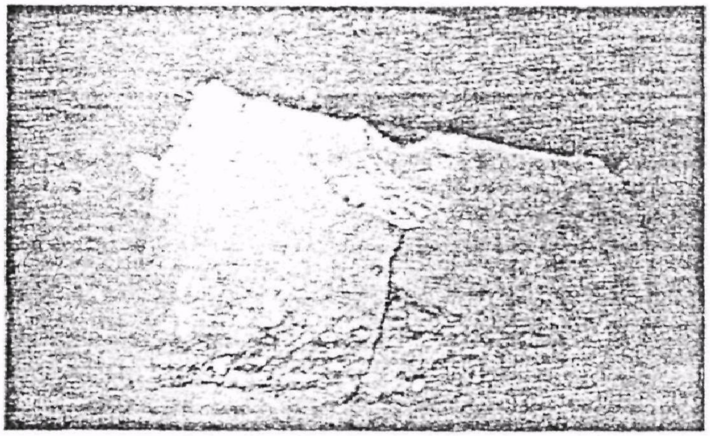
Frame 494 A barrel, pushed over by CURV III, that has numerous sponges attached. This is a good example of the many similarly-sighted barrels showing the potential for biological action on the container, and the propensity of some invertebrates to seek this substrate and other hard substrates for attachment.

Frame 496 Upright barrel with large sponge of the new genus of Hexactinellida attached. The area near the top left edge of the barrel, where some hydrozoans are seen, appears to be breached. Note that this barrel has a metal lid used infrequently in radioactive waste packaging during this period except possibly when experimentation with matrices other than concrete were being conducted.

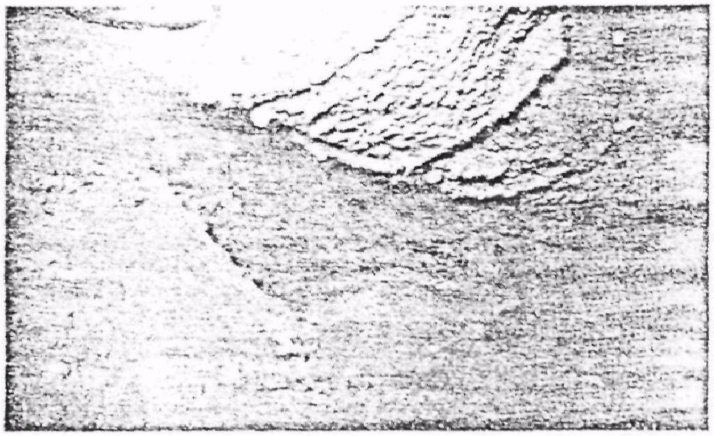
Frame 522 — When the CURV manipulator attempted to remove a sponge sample from this barrel also shown in Frame 496, the sponge fell away leaving the corroded inner matrix of the barrel exposed. The detached sponge still retained a large piece of the barrel along its base of attachment (not visible here). The metal of the barrel was corroded and flaky and the barrel may have had a bitumen liner. Note shrimp near lower middle right of photo just below manipulator cable.

TV 1 — Closeup of a barrel end - also shown in Frames 486 and 487. (The videotape TV record was all of poor quality for reproduction.)

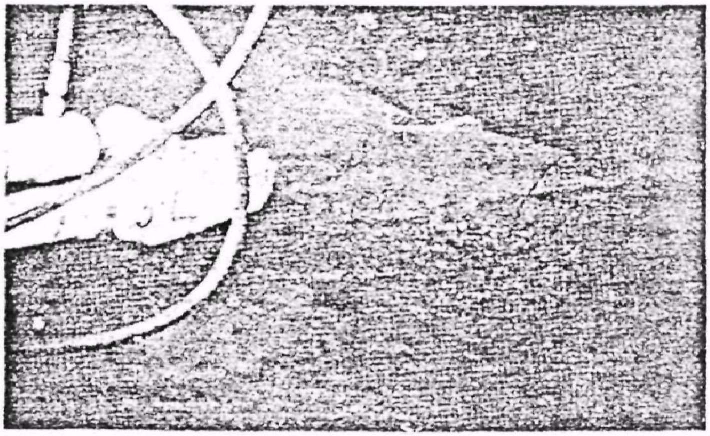
TV 2 — Closeup, from another angle, of the imploded area of the drum shown in Frame 404.



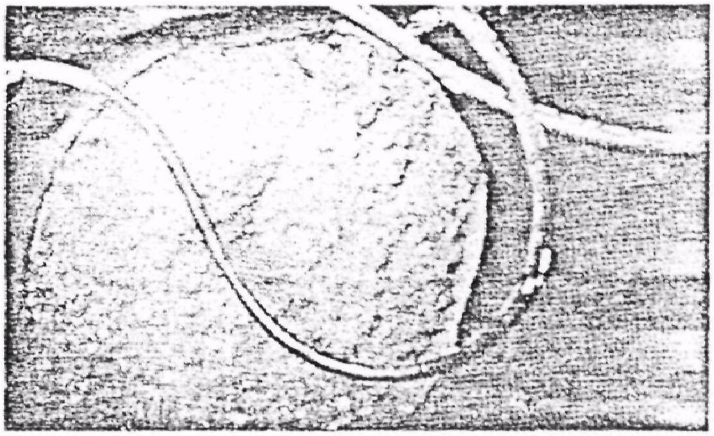
FRAME 357



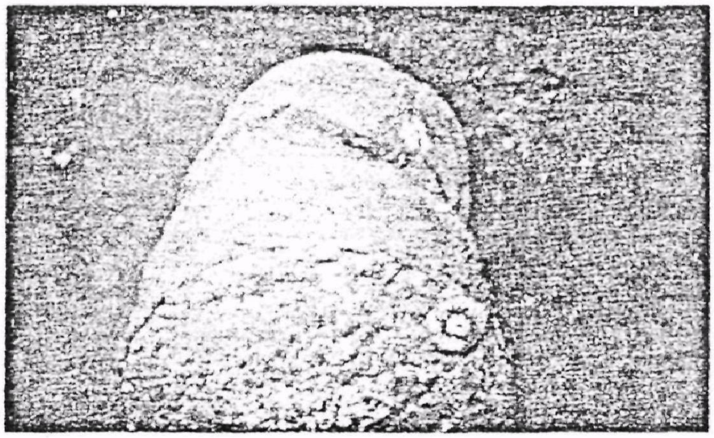
FRAME 364



FRAME 367

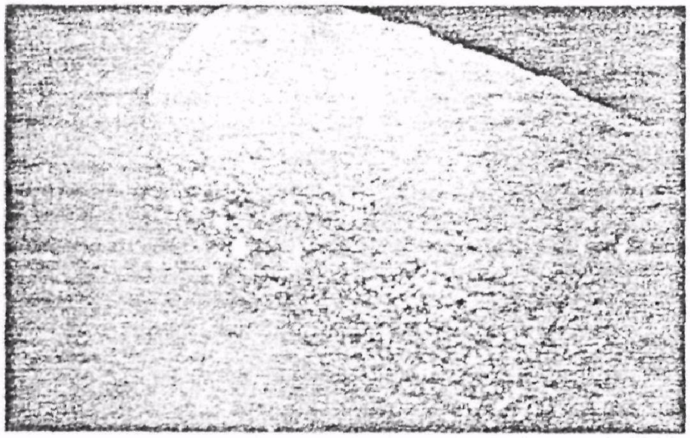


FRAME 372

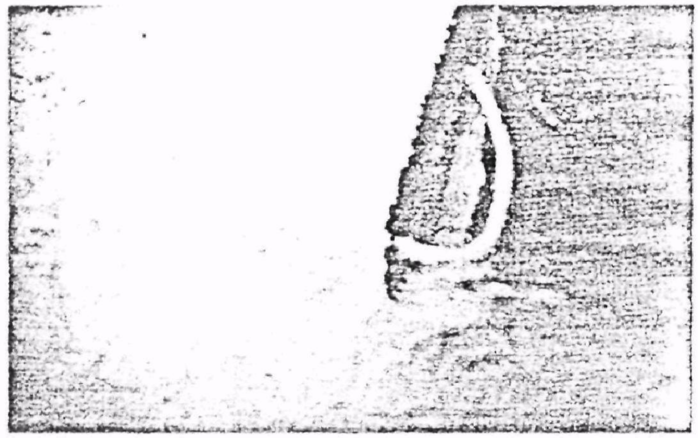


FRAME 374

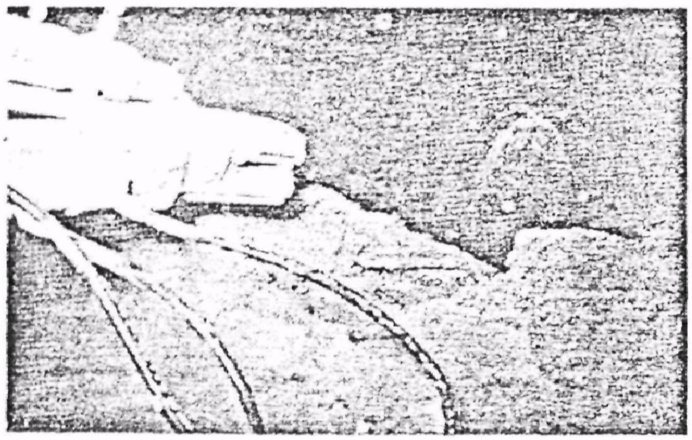
FRAME 379



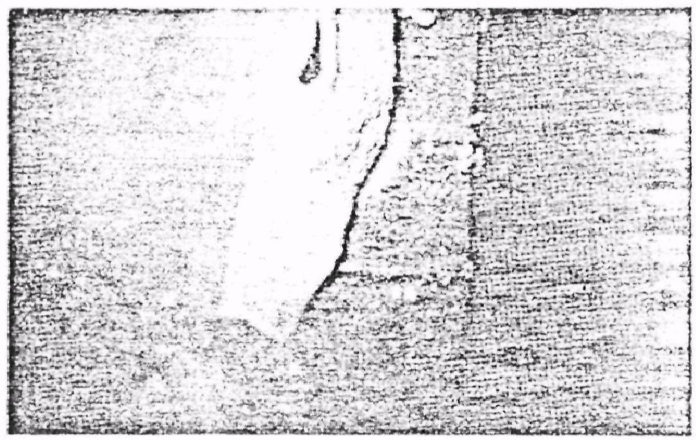
FRAME 388



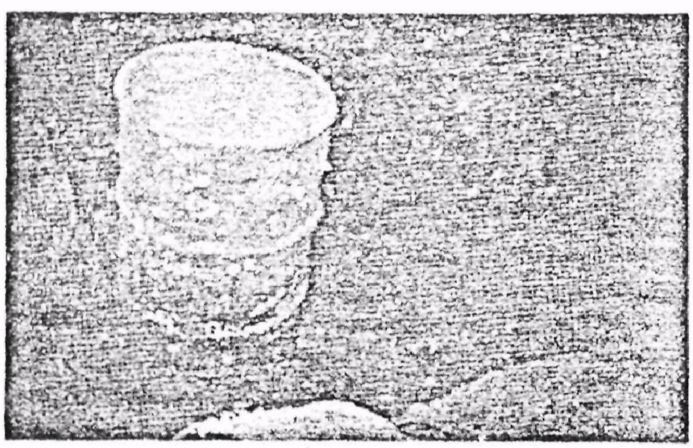
FRAME 403



FRAME 404



FRAME 409



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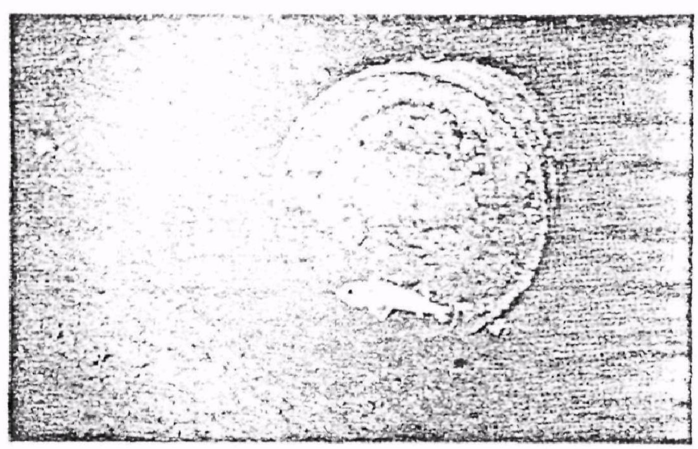

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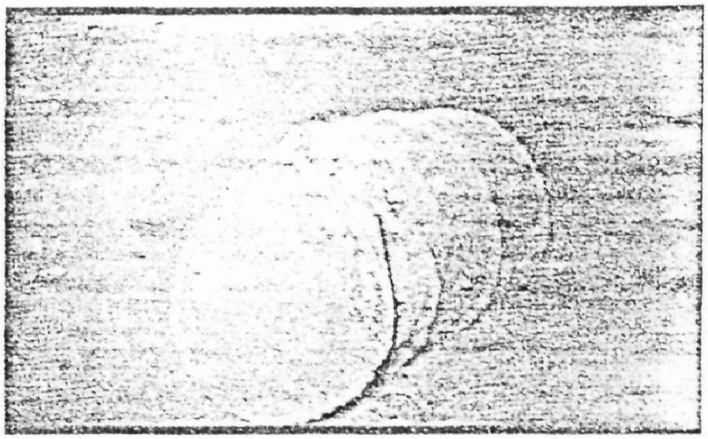

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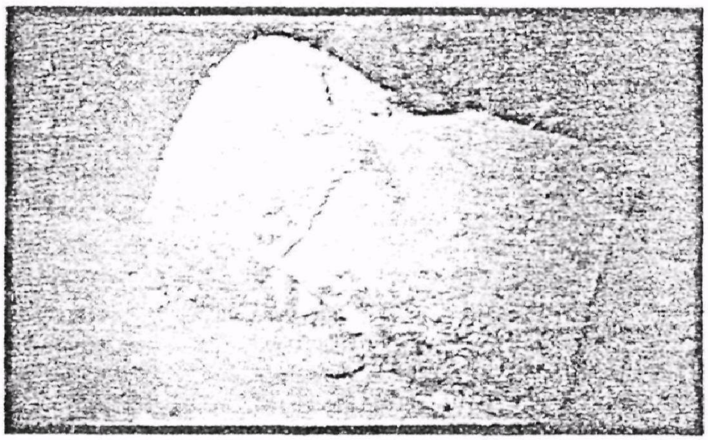

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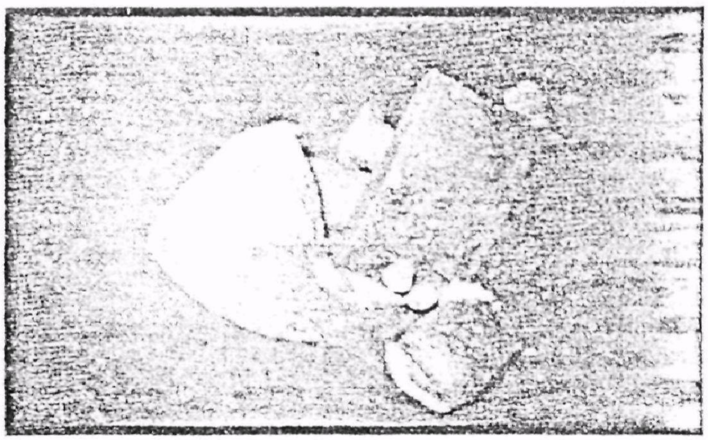

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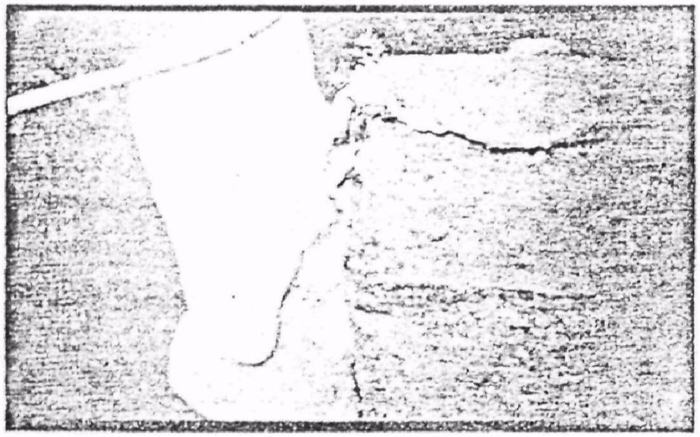

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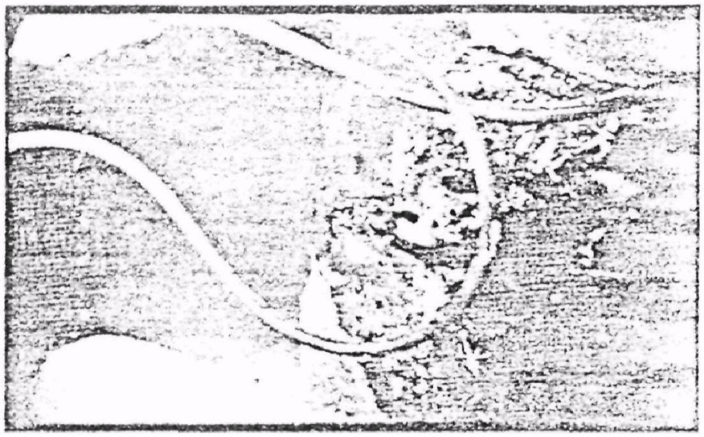

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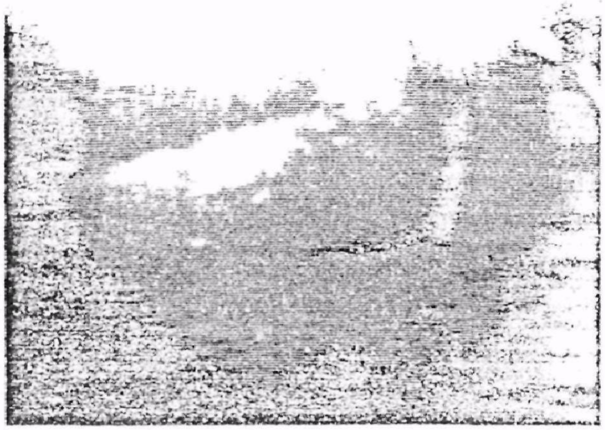

TV 2

Section 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 OPERATIONAL RECOMMENDATIONS

The field survey conclusively demonstrated the ability of the tethered underwater vehicle, CURV III, to perform highly-sophisticated investigative tasks at a depth of 500 fathoms (3,000 feet.) Of particular importance was the ability of CURV III to remain on a survey station for long periods of time.

As with any complex operation, there were areas that could be improved. The most important of these was the station-keeping ability of the CURV III support ship. This is a function of the type of surface support vessel. Station keeping with the M/V Gear was satisfactory when the class of vessel was considered. However, there were significant problems staying on station throughout the operation since the ship lacked lateral positioning equipment such as bow or stern thrusters. The launch and recovery of the CURV III also needed modification. The periods of highest risk to personnel and CURV III occurred during launch and recovery. In a July, 1974, operation for the Army Corps of Engineers, damage during launch was sufficient to abort the operation. A similar near-mishap occurred during this operation when a wave struck the ship, at a critical time during the launch, and caused CURV III to impact the vessel's side. Although the vehicle went on to perform its mission, the shock had been great enough to cause failure of the 35mm underwater camera spooling mechanism for one complete dive. For future programs the station keeping problem and launch/recovery risks could be minimized by the use of a support vessel better designed for the CURV III, such as the YFNX-30 boat operated by the Naval Undersea Center, although this would require a longer transit time to the study site and a second ship to tow the YFNX-30 boat.

There were several technical areas that could be improved by equipment modifications to the CURV III system. Although these problems were apparent, solutions were not implemented due to funding limitations. The following improvements should be considered for incorporation in future operations:

1. Precise 60 Hz Power Source - The power supply for the TV videotape recorder is presently a portable diesel generator. Unfortunately, frequency regulation is not precise enough to guarantee the ability to playback the video tape recordings from machines connected to shore 60 Hz mains. In the case of the Farallon operation, the original video tapes could not be played back on shore without extensive processing. This processing

resulted in the loss of resolution and, consequently, in the loss of valuable information. A separate, stable-frequency power supply should be installed for the videotape equipment.

2. Underwater Positioning - Precise location of the underwater vehicle with relation to the surface support ship was impossible. Use of the BALD (Boat Acoustic Locating Device) equipment provided a bearing but not a precise position. Without precise location information, the full capabilities of the vehicle cannot be realized. A sonar-type position plotting system should be considered.

3. Operational Convenience

   a. The video tape recorder should be modified for remote control to permit the unit to be secured in the cabinet. Control of the recorder was inconvenient. Use of the instrument on the desk could be hazardous in rough seas. Voice recording should be used extensively by an expert observer.

   b. Interior communications (between deck, control van, plotting room, etc.) was difficult. The 27 mHz handytalkies were noisy, and the operation was not convenient for the crew. Use of combined headset/FM transceivers should be considered.

c. Plotting could be greatly expedited by use of a digital printer connected to the BCD (Binary Coded Decimal) output of the Radio Positioning System. This would provide a digital printout of the ranges, eliminating the need for manual plotting and the possibility of human error. The system could be further automated by incorporating a standard American Standard Code for Information Interchange tape punch or mag tape recorder so that the plot data would be ready for computer entry without further hand processing.

8.2 CONCLUSIONS WITH RECOMMENDATIONS FOR FUTURE OPERATIONS

1. Review of the benthic photographs by members of the scientific community has resulted in expression of the need for collecting deepwater biological specimens in future operations. To do this properly, a biologist skilled in the identification of deepwater benthic species should be onboard as part of the scientific team to perform as much at-sea visual identification as possible.
2. There is a significant lack of information on ocean currents in deepwater dumpsite areas. Both short and long-term current measurements should be taken around dumpsites. Salinity-Temperature-Depth (STD) profiles

should also be taken to identify any water masses present which could ultimately act as pollutant dispersents.

3. Sediments are the most important indicators of short-term, aperiodic, and/or low-level radionuclide releases in areas with large dilution capacities. Any future operations should include extensive sediment collection for analysis of the presence and distribution of any released radionuclides.
4. Selected radioactive waste packages should be recovered for corrosion analysis of the metal sheath, and leach rate determinations of the concrete or other matrix material.

In summary, feasibility of using the CURV III for radioactive waste disposal site monitoring has been successfully demonstrated at the 500-fathom site near the Farallon Islands and has provided the following information:

1. The radioactive wastes were found in the general dumpsite area as reported by Joseph, 1957.
2. The containers had the unique packaging configuration described in the disposal records.
3. None of these radioactive waste packages showed any evidence of failure of the concrete plugs either by

being forced inward or popped out due to the high hydrostatic pressure.

4. The unmanned undersea vehicle performed as required.
5. The photographic documentation (as presented in Section 7) provided useful information on the condition of the drums.
6. Precisely-located core samples could be obtained next to radioactive waste containers, in this case at Station 13 (A and B) (Table 5-1).
7. The biological activity in the area was high with at least one commercial species of fish, Anoplopoma (sable fish) being present in the dumpsite area.

It has now been established that varying degrees of container deformation have occurred to many of the 55-gallon radioactive waste drums observed at the 500-fathom depth. The question now arises: What sort of predictions can be made about radioactive waste container integrity at the 1,000-fathom dumpsite, considering that 2,000 meters (approximately 1,100 fathoms or 6,600 feet) is the present internationally acceptable minimum disposal depth for ocean dumping of low-level radioactive wastes?

It is recommended that a subsequent survey be made at the 1,000-fathom radioactive waste dumpsite near the Farallon Islands.

Section 9

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